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# THE HALF LIFE OF CALCIUM 45.

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CALCIUM 45 is a soft beta emitter ($E_{max.} = 0.25$ MEV.) which is being increasingly used in biological studies. Its half life has been estimated by Walke, Thompson and Holt[1] to be 180 $\pm$ 10 days, and by Matthews and Pool to be 152 days. The rather large discrepancy of about 20% between these values made a redetermination seem desirable. The purpose of this paper is to report such a determination.

18 g. of 'Analar' calcium carbonate were irradiated for about a day in the pile at Harwell, to a total activity of a few microcuries. Approximately 2.3 g. of this were placed in a brass holder below a G.E.C. end-window geiger counter, type EHM2. This counter had a window of diameter 24 mm., and thickness 2.1 mg./cm$^2$. Its anode was held at 1470 volts by a stabilised power-pack, and its cathode run to earth through a 3.3 megohm resistor. The positive pulses at the cathode were inverted and amplified by an Osram H63 triode, and fed to a Model 400 Los Alamos type scale of 64 recorder. The counter background was reduced to about 13 per minute by shielding all round with 1 in. of lead, lined with aluminium, with an additional $\frac{3}{4}$ in. of lead on top. Small day to day variations in the counter response were corrected for by counting a standard uraninite source giving about 3,500 counts per minute. No two readings on this standard, however, differed by more than 2%. A reproducible geometry was assured by having the source holder sliding in on rails to a fixed stop. Also since the source to window distance is quite large, (2.80 cm.) any residual errors of this type will be very small indeed.

The holder had an internal diameter of 3.6 cm. and a depth of 0.66 cm., and the calcium carbonate filled it to a depth of about 0.4 cm. The top was sealed off with cellophane of superficial mass 3.6 mg./cm$^2$., to prevent any change or losses. Even with the maximum available distance of 2.8 cm. between holder and counter window, the count per second under these circumstances was too large to be conveniently handled by the register of the scaler. A brass disc bored with a 1.75 cm. diameter hole and placed directly on the holder, cut this down to a more manageable figure.

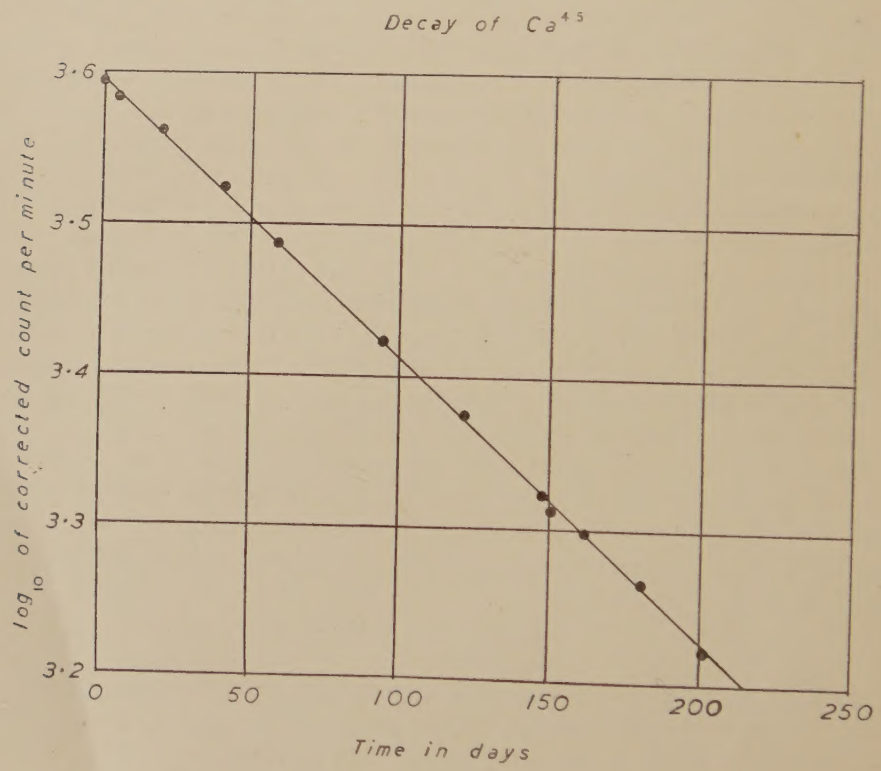
The activity was followed for a period of 202 days, in which time it fell from 3934 counts/min. to 1668 counts/min., as shown in the accompanying graph. Here, since the activity falls off exponentially, a semi-logarithmic scale (to the base 10 for convenience) has been used. Each point represents the result of about 100,000 counts. The line has been fitted by the method of least squares, and has a slope of 0.0018427. Since, with the usual notation, $n = n_0 e^{-\lambda t}$, and T, the half life, is defined as $\log_e 2/\lambda$, we have

$$T = \log_{10} 2/\text{slope of graph}$$
$$= 163.4 \text{ days.}$$

The calculated probable error is 0.73 days, and the maximum error, five times this, 3.65 days. The result may therefore finally be quoted as 163.5 $\pm$ 4 days. This is very nearly the mean of the two previous determinations.

For the preceding result to be of any value it is of course essential that the radioactivity being measured is from $Ca^{45}$ alone, and not from any other substance. Quite large activities could be produced, not only from the carbon and oxygen present in the carbonate, but also from any minute impurities present, if these have a large cross section for neutron capture. It is therefore imperative to examine carefully the nature and amounts of all radioisotopes produced during the irradiation.

The matter is, however, simplified by the fact that over 100 days were allowed to elapse between the removal of the material from the pile and the first measurement. Consequently all radioisotopes with half lives less than, say, 10 days can be considered to have disappeared almost completely. Bearing this in mind, an examination of a table of isotopes in conjunction with the 'Analar' specification of calcium carbonate, was made. This showed that only the following substances (mostly produced by $n,\gamma$ reactions) were likely to cause trouble ;—$C^{14}$, $Na^{22}$, $P^{32}$, $S^{35}$, $Cl^{36}$, and $Fe^{59}$. To obtain a measure of the amounts of these present, the percentage number of atoms of the parent substance present was multiplied by its neutron cross section. The numbers thus obtained were divided by their respective half lives to give the relative activities, i.e. counts per minute, which would be produced. Finally an allowance was made for decay during the 100 days which had elapsed since irradiation. It was then found that the largest contribution would be from $S^{35}$, but that this would only amount to about 0.08% of the main calcium activity.



We may thus be sure that, to within the limits of experimental error, the decay of $Ca^{45}$ alone is being measured. This is confirmed both by the Harwell specification of radioactive impurities present in the calcium carbonate, and by the plot of the activity itself. The presence of any other radioactivity besides that of $Ca^{45}$ would show up as a departure from linearity of the graph.

Summary.

The half life of calcium 45 has been redetermined by following its decay with an end window geiger counter for over 200 days. The result is 163.5 days with a calculated maximum error of $\pm 4$ days.

Bibliography.

1. H. Walke, F. C. Thompson, and J. Holt, Phys. Rev. 57, 177, (1940).
2. D. E. Matthews and M. L. Pool, Phys. Rev. 72, 163(A), (1947).